3

LOCATION

Objective:	To review the system of latitude and longitude, and provide experience using atlases and globes.
Materials:	25 cm (10 inch) or larger diameter globe. World atlas (with index).
Reference:	McKnight and Hess, *Physical Geography*, 8th ed., pp. 9–15.

LATITUDE AND LONGITUDE

Any location on Earth can be described using the grid system of **latitude** and **longitude**. Latitudes and longitudes are angular measures, with latitude describing north-south location, and longitude describing east-west location.

Lines of latitude on a map or globe are called **parallels** since they are all parallel to each other (Figure 1a). Latitude ranges from 0° at the equator, to 90° north latitude at the North Pole, and 90° south latitude at the South Pole.

Lines of longitude are known as **meridians** (Figure 1b). The meridians are farthest apart at the equator and converge at the poles.

The starting point for measuring longitude is the **prime meridian**, which runs through the Royal Observatory at Greenwich, England (just outside London). Locations east of the prime meridian are described in degrees east longitude, and locations west of the prime meridian in degrees west longitude. Longitude ranges from 0° at the prime meridian to 180° (on the opposite side of the Earth from the prime meridian).

When more exact descriptions of location are required (as when using detailed maps of a region), fractions of degrees of latitude and longitude are used. One degree is divided into 60

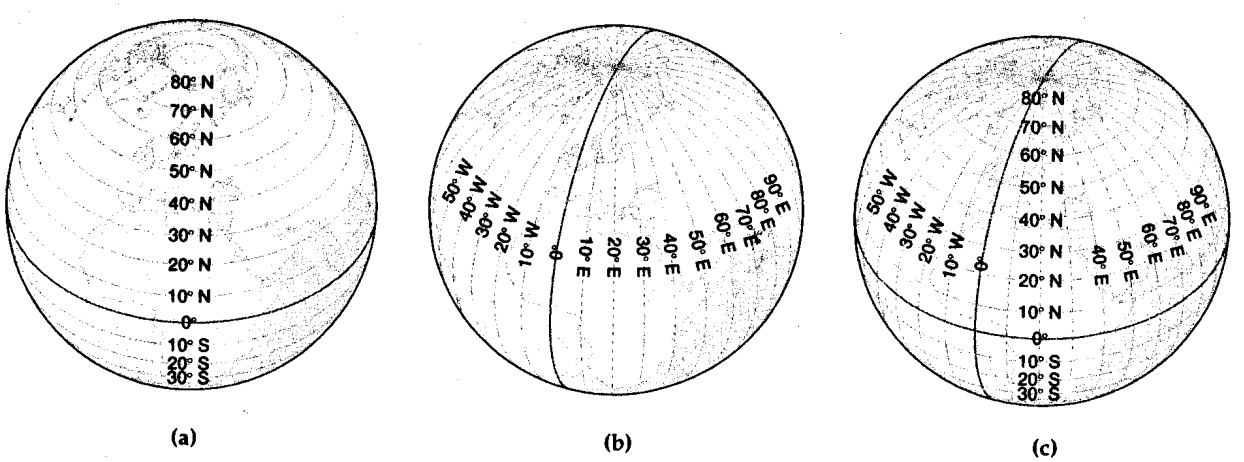


Figure 1: The geographic grid: (a) Parallels of latitude. (b) Meridians of longitude. (c) Complete grid system. (From McKnight and Hess, *Physical Geography*, 8th ed.)

"minutes" (often written 60') and each minute can be further divided into 60 "seconds" (60"). Therefore: 1° = 60' and 1' = 60". When describing angular measures such as latitude and longitude, minutes and seconds are *not* referring to time, but to fractions of degrees.

As an example, the precise location of the crater of Mount St. Helens in Washington is 46°11'55" north latitude, 122°11°15" west longitude.

With the increasing use of **Global Positioning System (GPS)** satellite technology to determine location, it has become common in some circumstances to indicate fractions of degrees in decimal units. For example, 45°35' N can be written 45.583° N, while 32°23'55" N can be written 32°23.917' N.

GLOBES AND ATLASES

Parallels and meridians are typically marked on globes in 10° or 15° increments. If the parallels and meridians are not marked on the globe, latitude and longitude are determined by using the degree markings on the arms or rings supporting the globe.

When searching for a location in an atlas, take advantage of the atlas index. The index will often comprise more than one-third of the pages in an atlas. In the index, cities, rivers, mountains, and other features are listed alphabetically. For each location, the index will typically provide the page number of the best map to use, the country, and often its latitude and longitude. Some atlases provide a pronunciation guide as well.

Some atlases do not refer to places in the index by latitude and longitude. Instead they provide a coordinate (such as "F7") that refers to a simplified grid system marked along the margins of each map in the atlas.

Name _____ Section _____

PROBLEMS—PART I

1. Using a globe, determine the latitude and longitude (to the nearest degree) of the following cities. Be sure to indicate if the location is north or south latitude, and east or west longitude.

	City	Latitude	Longitude
(a)	Chicago, Illinois	_____	_____
(b)	Tokyo, Japan	_____	_____
(c)	Sydney, Australia	_____	_____
(d)	Singapore	_____	_____
(e)	Buenos Aires, Argentina	_____	_____

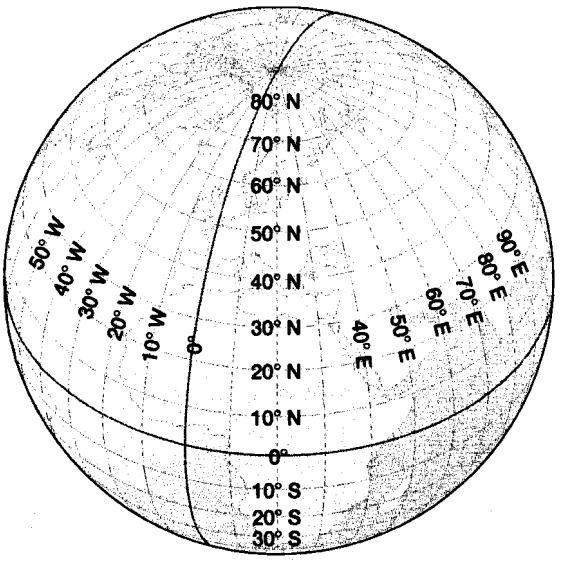
2. Using a globe, determine which major city is located at the following coordinates:

	Latitude	Longitude	City
(a)	14° N	100° E	_____
(b)	56° N	38° E	_____
(c)	19° N	99° W	_____
(d)	1° S	37° E	_____
(e)	37° S	175° E	_____

Name _____ Section _____

PROBLEMS—PART II

1. On the diagram at right, plot the following coordinates with a dot. Then label each dot with its corresponding letter:



(a) 10° N, 40° W

(b) 50° N, 40° E

(c) 40° N, 25° W

(d) 5° S, 10° W

(e) 65° N, 70° E

2. Use the index of an atlas to find the following places. Determine the latitude and longitude to the nearest degree:

	Place	Latitude	Longitude
(a)	Pusan	_____	_____
(b)	Reykjavik (Reikjavik)	_____	_____
(c)	Walvis Bay	_____	_____
(d)	Tuvalu (Ellice Islands)	_____	_____

3. If you start at the equator and travel to 10° N latitude, approximately how many kilometers (or miles) north of the equator will you be? Take the circumference of the Earth to be 40,000 kilometers (24,900 miles). Show your calculations.

4. If you travel west through 10° of longitude along the equator, the distance traveled will be very different from the distance traveled through 10° of longitude at 60° N latitude. Why?

4

TIME

Objective: To learn to calculate time and day differences around the world.

Reference: McKnight and Hess, *Physical Geography*, 8th ed., pp. 22–27.

LOCAL SUN TIME

Although few people today are concerned with the local **Sun time**, it is a useful starting point for a discussion of time. Local Sun time is based on the position of the Sun in the sky. The local Sun time "noon" for a given location is the moment in the day when the Sun reaches its highest point in the sky. However, at the same moment that it is local Sun time noon at our location, at locations east or west of us the local Sun time is different.

The Earth rotates from west to east (looking down at the North Pole on a globe, the Earth would appear to be spinning counterclockwise). This means that at the same moment the Sun is low in the morning sky in Honolulu, it is high in the sky at noon in Denver, and low in the afternoon sky in New York. In other words, as we travel to the east, the time becomes progressively later.

STANDARD TIME

Rather than having people continually adjusting clocks to local Sun time when moving east or west, 24 **standard time zones** have been established by international agreement. Each time zone is a band of longitude, within which it is the same standard time (although, of course, the local Sun time varies slightly within the time zone). When moving from one time zone to the next, we adjust our watches by one hour.

The time zones are based on **central meridians** spaced 15° of longitude apart. The Earth rotates through 360° of longitude in 24 hours, and so rotates through 15° of longitude in one hour ($360° \div 24 = 15°$). While a standard time zone is 15° of longitude wide, the actual time zone boundaries have been adjusted over most inhabited areas of the Earth (Figure 1).

TIME ZONE CALCULATIONS

The map in Figure 1 shows standard time zones around the world. If we remember that it is always later in New York than in San Francisco, it is easy to calculate time differences. It becomes one hour later for each time zone we cross moving from west to east (from San Francisco toward New York), and one hour earlier for each time zone we cross moving from east to west. New York is three time zones to the east of San Francisco, so New York time is three hours later than San Francisco time.

To avoid confusion, it is usually best to refer to "12:00 midnight" and "12:00 noon" rather than to 12:00 A.M. and 12:00 P.M. respectively.

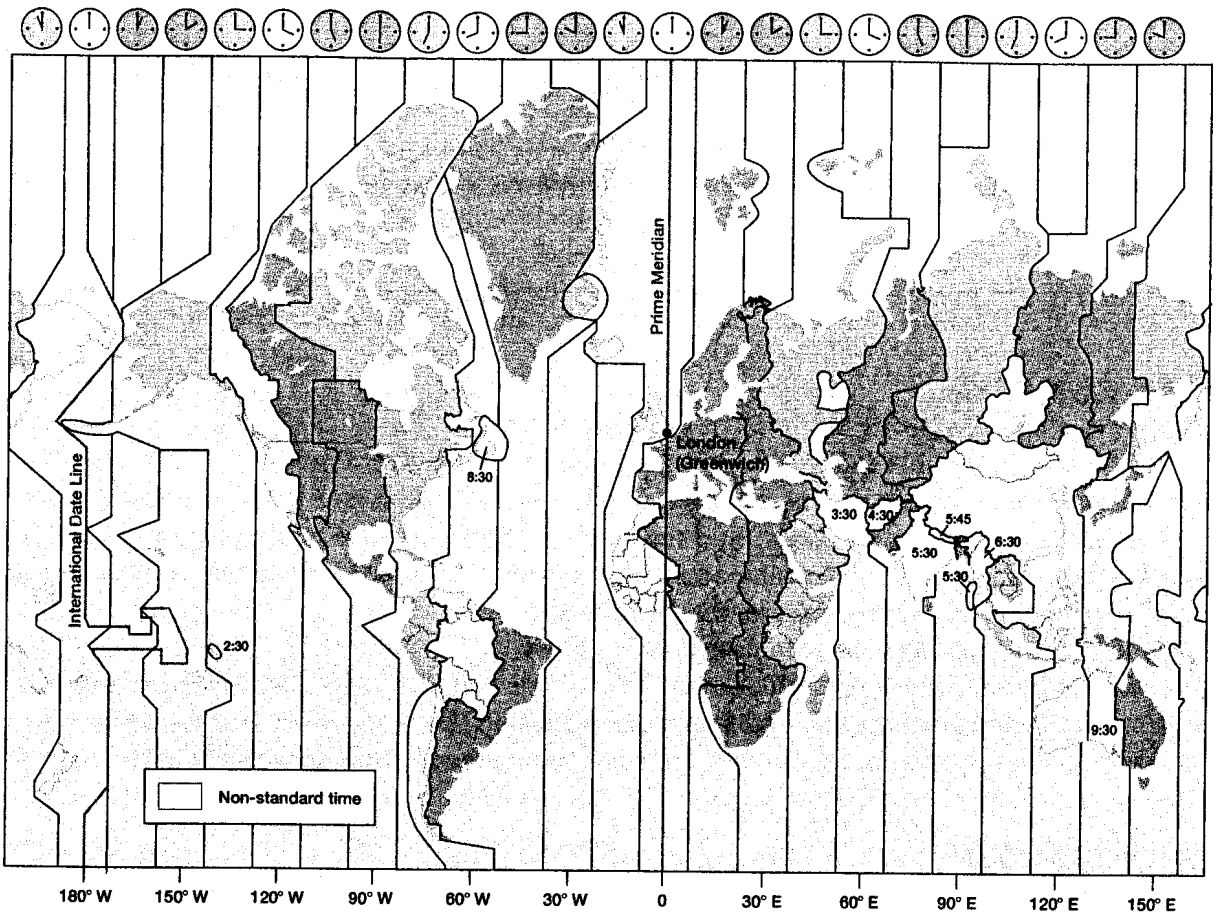


Figure 1: Standard time zones of the world. (From McKnight and Hess, *Physical Geography*, 8th ed.)

Notice that a few time zones are based on the half-hour (such as for Newfoundland and India), but the same logic applies. For example, India is 5 1/2 hours later than Greenwich, England.

In 1884, **Greenwich Mean Time (GMT)** was established as the world reference for standard time (the Greenwich time zone is based on the prime meridian). Today, Greenwich time is known as **Universal Time Coordinated (UTC)** or **Zulu** time (Zulu time uses a 24-hour clock, so that "1530Z" would be 3:30 P.M. Greenwich time).

If you know the central meridians, it is also possible to calculate time differences mathematically by determining the number of degrees of longitude between two locations. For example, Tokyo time is based on the 135° E central meridian and Rome is based on the 15° E meridian, a difference in longitude of 120°:

$$135° - 15° = 120° \text{ difference between Tokyo and Rome}$$

Fifteen degrees of longitude represents one hour of time, so:

$$120° \div 15° = 8 \text{ hours difference between Tokyo and Rome.}$$

Since Tokyo is east of Rome, the time will be eight hours later in Tokyo than in Rome.

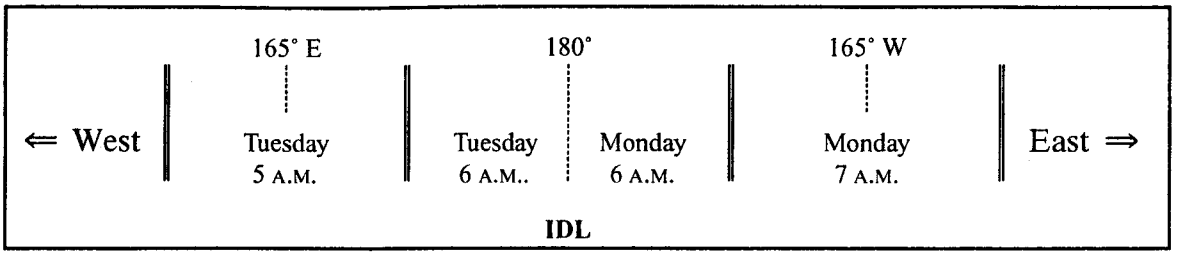


Figure 2: International date line (IDL) and bordering time zones, shown here with their central meridians.

INTERNATIONAL DATE LINE

When determining time differences between two places around the world, remember that the day may also be different. The day changes under two circumstances. First, the day changes at midnight. When traveling from west to east, when we cross into the time zone where it is midnight, it becomes the next day. Conversely, when traveling from east to west, when we cross into the 11 P.M. time zone it becomes the previous day.

The day also changes at the **international date line** (IDL), which generally follows the 180° meridian down the middle of the Pacific Ocean. When crossing the IDL going from west to east (from Japan toward Hawaii), it becomes the previous day. When crossing the IDL going from east to west (from Hawaii toward Japan), it becomes the next day.

The international date line runs down the middle of a time zone. When first entering into this time zone, the hour changes, but the day remains the same until crossing the IDL (at which point only the day changes, not the time). Figure 2 shows the international date line and the bordering time zone boundaries. Sample times and days are shown in the diagram.

DAYLIGHT-SAVING TIME

A variation of standard time is **daylight-saving time**. Daylight-saving time is used throughout most of the United States during part of the year. In the summer, the days are longer than in the winter, and so there is a period of daylight that is "wasted" in the morning before people go to work. By shifting time ahead by one hour, there is, in effect, an "extra" hour of daylight in the afternoon after people come home from work. Most of the United States goes on daylight-saving time on the first Sunday of April, and goes back to standard time on the last Sunday of October.

Daylight-saving time calculations are easy. Simply remember the saying: "spring forward, and fall back." In other words, in the spring when going on daylight-saving time, we "spring forward" by adding one hour. When returning to standard time in the fall, we "fall back" by subtracting one hour.

When calculating time differences around the world, if both cities are observing daylight-saving time, you need not change your calculation procedure. If, for example, only the first city is observing daylight-saving time, convert that city back to standard time (by subtracting one hour), then proceed with your calculations as before.

SUNRISE AND SUNSET TIME CORRECTION

Local news media often provide us with the time of sunrise and sunset calculated specifically for our city. Because the local Sun time varies if we move east or west, the actual time of sunrise and sunset at locations east or west will vary slightly from that stated for our city. In locations to the east of our city, the exact time of sunrise and sunset will be earlier, while in locations to the west, the exact time will be later.

The sunrise/sunset time correction for different longitudes is easy to calculate. The Earth rotates through 15° of longitude in one hour. Therefore, the Earth rotates through 1° of longitude in 4 minutes (60 minutes ÷ 15° = 4 minutes per 1°). Locations to the east of us will experience sunrise/sunset four minutes earlier for each degree of longitude. Locations to the west will experience sunrise/sunset four minutes later for each degree of longitude. Note: this ignores differences in latitude which may also affect the sunrise/sunset time.

For example, if the stated sunset time for 75° W is 6:15 P.M., at 73° W, sunset will occur 8 minutes earlier (at 6:07 P.M.), while at 78° W, sunset will occur 12 minutes later (at 6:27 P.M.).

Name _____ Section _____

PROBLEMS—PART I

Using the longitude of a time zone's central meridian (which has been provided for you), answer the following questions. Be sure to indicate if the time is A.M. or P.M.; however, refer to "noon" or "midnight" rather than to 12:00 P.M. or 12:00 A.M. It may be helpful to draw a simple diagram, such as Figure 2, when making your calculations.

1. If it is 10:00 A.M. Monday in Denver (based on 105° W), what time and day is it in New York City (75° W)?

2. If it is 11:00 A.M. Thursday in Seattle (120° W), what time and day is it in Seoul, South Korea (135° E)?

3. A satellite image of the United States was taken at "0900Z." What was the local standard time in Chicago (90° W)?

4. If it is Friday at 3:00 P.M. daylight-saving time in Kansas City (90° W), what is the day and time in Quito, Ecuador (75° W), where daylight-saving time is not being observed?

Name _____ Section _____

PROBLEMS—PART II

1. (a) Your plane leaves Boston (75° W) at 7:00 A.M. on Saturday, bound for Los Angeles (120° W). The flight takes 5 hours. What is the time and day when you arrive in Los Angeles?

   (b) Your connecting flight to Taipei (120° E) leaves Los Angeles at 1:00 P.M. on that same day. The flight takes 11 hours. What is the time and day when you arrive in Taipei?

2. For a given latitude, if the stated time of sunset is 6:45 P.M. at 90° W, what is the time of sunset at 91° W?

3. For a given latitude, if the stated time of sunrise is 6:10 A.M. at 120°00' W, what is the time of sunrise at 117°30' W?

Calculating Time

It takes 24 hours for the earth to complete one rotation around the sun, that is 360^0. Time is determined by where you are located in relation to the earth's rotation around the sun. For example, during the "day" you are located within the Circle of Illumination-the area of the earth receiving the suns rays. As the sun sets, your location is rotating out of the Circle of Illumination to the backside of the earth. Meanwhile another location is rotating into the Circle of Illumination.

The time that it takes for the earth to rotate 1^0 long. = 4 minutes. In 1 hour the earth rotates 15^0 long. The earth rotates eastward, therefore the sun appears to rise in the east and set in the west. The earth has been divided up into time zones that generally correspond to 1-hour intervals, every 15^0 of long, starting with the Prime Meridian (0^0) – (Greenwich Mean Time). Each time zone is based on a Central Meridian.

International Date Line

While time changes every 15^0, the day changes in two ways.

1. After Midnight
2. Crossing the International Date Line (180^0)

When crossing the IND heading east – subtract 1 day: Friday becomes Thursday
When crossing the IND heading west – add 1 day: Friday becomes Saturday

1) If it is noon in Greenwich, what time would it be at:

a. 15^0 E? _____

b. 30^0 E? _____

c. 15^0 W? _____

d. 45^0 W? _____

2) What is the Central Meridian for the Pacific Standard Time Zone?

3) Use the time zone map to calculate the standard time for the following locations.

	Location	Day	Time	Location	Day	Time
a.	Los Angeles	Tues.	3:00pm	New York	_____	_____
b.	Paris	Mon.	10:00am	Seattle	_____	_____
c.	Buenos Aires	Sun.	9:00pm	Cape Town	_____	_____
d.	Hanoi	Fri.	8:00am	Los Angeles	_____	_____
e.	Honolulu	Wed.	6:00pm	Tokyo	_____	_____